

## PATENT ABSTRACTS OF JAPAN

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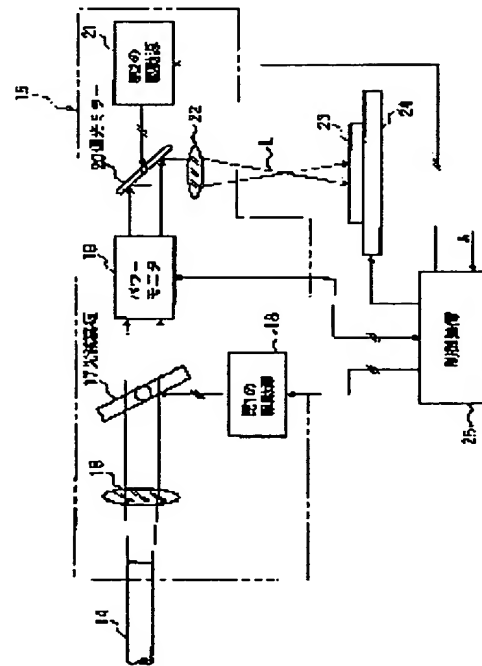
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## (54) LASER BEAM MACHINING DEVICE

(57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a laser beam machining device with which displacement of an irradiation position caused by the refraction of the laser beam is prevented when the strength of the laser beam is controlled by using a light attenuator board.

**SOLUTION:** A laser beam machining device with which a work piece 23 is machined by irradiation of a laser beam L is provided with a laser oscillator with which the laser beam L is outputted, a light attenuating board 17 the turning angle of which is adjustable and with which the strength of the outgoing laser beam L is controlled by changing the incidence angle of the laser beam L, a polarizing mirror 20 through which a work piece 23 is irradiated with the laser beam L the strength of which is controlled with this light attenuating board, and a control device 25 which detects a rotating angle of the light attenuating board 17, calculates the deviated amt. of the optical axis of the laser beam L generated with the light attenuating board 17 according to the rotating angle and corrects, based on the calculated value, the irradiation position of the laser beam L irradiating the work piece 23 through the polarizing mirror 20.



## LEGAL STATUS

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CLAIMS

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[Claim(s)]

[Claim 1] In the laser-processing equipment which irradiates and carries out laser processing of the laser beam to a workpiece The optical attenuating means which controls the reinforcement of the laser beam which carries out outgoing radiation by it being prepared possible [ the laser oscillation machine which outputs the above-mentioned laser beam, and adjustment of angle of rotation ], and changing whenever [ incident angle / of the above-mentioned laser beam ], The Mitsuteru gunner stage which irradiates the laser beam by which reinforcement was controlled by this optical attenuating means at the above-mentioned workpiece, The amount of gaps of the optical axis of the above-mentioned laser beam which detects angle of rotation of the above-mentioned optical attenuating means, and is produced in the above-mentioned optical attenuating means according to the angle of rotation is computed. Laser-processing equipment characterized by providing an amendment means to amend the exposure location of the laser beam which controls the above-mentioned Mitsuteru gunner stage by the calculation value, and irradiates a workpiece.

[Claim 2] It is laser-processing equipment according to claim 1 or 2 which the above-mentioned Mitsuteru gunner stage consists of the deviation mirror which deflects the direction of the above-mentioned laser beam, a driving means which changes the include angle of this deviation mirror, and an optical lens which converges the laser beam reflected by the above-mentioned deviation mirror, and is characterized by the above-mentioned amendment means controlling the include angle of the above-mentioned deviation mirror.

[Claim 3] The above-mentioned Mitsuteru gunner stage is X scanner which makes the above-mentioned laser beam scan in the direction of X on a workpiece, and laser-processing equipment according to claim 1 or 2 characterized by the thing of the above-mentioned X scanner or Y scanner for which one of drives are controlled at least according to the gap direction of the optical axis of the laser beam consist of a scan \*\*\*\* Y scanner in the direction of Y, and according [ the above-mentioned amendment means ] to the above-mentioned optical attenuating means.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the laser-processing equipment into which it adjusts to the reinforcement of a request of a laser beam, and a workpiece is processed.

[0002]

[Description of the Prior Art] To process it by the laser beam of the reinforcement which changes two or more processing points in the laser-processing equipment into which a workpiece is processed with laser beams may be demanded. Drawing 6 shows the conventional laser-processing equipment in such a case. One in the said drawing passes the photodetector 2 which detects the reinforcement of that laser beam L, and carries out incidence of the laser beam L which is laser oscillation machines, such as an YAG laser, and was outputted from this laser oscillation machine 1 to the optical exposure unit 3. Although not illustrated, the deviation mirror, the optical lens, etc. are built in, and this optical exposure unit 3 converges laser beam L which carried out incidence here, and irradiates a workpiece 10.

[0003] The detecting signal from the above-mentioned photodetector 2 is inputted into a control unit 4. This control unit 4 compares the set point A with a detection value, and controls the current value by the power source 5 which excites the above-mentioned laser oscillation machine 1 according to that comparison. It enables it to change the reinforcement of laser beam L from the laser oscillation machine 1 into the set point set as the above-mentioned control unit 4 by it.

[0004] However, if it does in this way and the reinforcement of laser beam L is controlled, after changing the current value of a power source 5, by the time the output of laser beam L oscillated from the laser oscillation machine 1 becomes the set point, the time amount of a unit will take several seconds. Therefore, since the processing point of a workpiece 10 is unchangeable at high speed (rate of ms unit), it may be said that last thing cannot do processing efficiency on \*\*.

[0005] Then, in order to enable it to change the output of laser beam L at high speed, the optical attenuation plate 6 shown in drawing 7 is used. This optical attenuation plate 6 can be formed between the laser oscillation machine 1 and a photodetector 2, and can change now whenever [ whenever / tilt-angle / to the optical axis of laser beam L ], i.e., whenever [ incident angle / of laser beam L ], by the driving source 7.

[0006] The attenuation factor of laser beam L which carries out outgoing radiation from this optical attenuation plate 6 changes because whenever [ incident angle / of laser beam L to the optical attenuation plate 6 ] changes. Therefore, the reinforcement of laser beam L is changeable by controlling the include angle of the above-mentioned optical attenuation plate 6 by the driving source 7 according to the reinforcement of laser beam L which a photodetector 2 detects.

[0007] If the include angle of the optical attenuation plate 6 is controlled, since a speed of response can be made quick compared with the case where change the current value of the power source 5 of the laser oscillation machine 1 like drawing 6 , and the reinforcement of laser beam L is controlled, it becomes possible to change a processing point at high speed.

[0008] However, according to the refractive index of this optical attenuation plate 6, an optical

axis shifts from the optical attenuation plate 6 laser beam L which carries out outgoing radiation. Therefore, outgoing radiation is carried out from the optical attenuation plate 6, the exposure location of laser beam L which converges in the optical exposure unit 3 and irradiates a workpiece 10 shifts, and it may be said that process tolerance falls.

[0009] In order to amend the optical-axis shift with the optical attenuation plate 6, it is possible to form an optical-path corrector plate in the optical attenuation plate 6 and a mirror plane object, to synchronize these, and to drive. However, in order that an optical-path corrector plate may lessen the transparency loss of a laser beam, an acid-resisting coat is given to both sides. The permeability of an acid-resisting coat changes with whenever [ incident angle / of laser beam L ].

[0010] Therefore, it may be said that it becomes impossible to set up correctly the reinforcement of laser beam L which irradiates about [ that the transparency loss of laser beam L arises with this optical-path corrector plate ], and a workpiece 10.

[0011]

[Problem(s) to be Solved by the Invention] Thus, since an optical axis will shift by a laser beam being refracted with the above-mentioned optical attenuation plate although a strong switch can be performed at high speed if the reinforcement of a laser beam is controlled using an optical attenuation plate, that process tolerance falls arises.

[0012] When the reinforcement of a laser beam is controlled using an optical attenuating means, even if the optical axis of a laser beam shifts by this optical attenuating means, offering the laser-processing equipment which amends that gap and enabled it to irradiate a workpiece has this invention.

[0013]

[Means for Solving the Problem] In the laser-processing equipment which invention of claim 1 irradiates a laser beam at a workpiece, and carries out laser processing The optical attenuating means which controls the reinforcement of the laser beam which carries out outgoing radiation by it being prepared possible [ the laser oscillation machine which outputs the above-mentioned laser beam, and adjustment of angle of rotation ], and changing whenever [ incident angle / of the above-mentioned laser beam ], The Mitsuteru gunner stage which irradiates the laser beam by which reinforcement was controlled by this optical attenuating means at the above-mentioned workpiece, It is characterized by providing an amendment means to amend the exposure location of the laser beam which computes the amount of gaps of the optical axis of the above-mentioned laser beam which detects angle of rotation of the above-mentioned optical attenuating means, and is produced in the above-mentioned optical attenuating means according to the angle of rotation, controls the above-mentioned Mitsuteru gunner stage by the calculation value, and irradiates a workpiece.

[0014] Invention of claim 2 consists of the deviation mirror from which the above-mentioned Mitsuteru gunner stage deflects the direction of the above-mentioned laser beam, a driving means which changes the include angle of this deviation mirror, and an optical lens which converges the laser beam which reflected by the above-mentioned deviation mirror in invention of claim 1, and it is characterized by the above-mentioned amendment means controlling the include angle of the above-mentioned deviation mirror.

[0015] Invention of claim 3 consists of a scan \*\*\*\* Y scanner in X scanner with which the above-mentioned Mitsuteru gunner stage makes the above-mentioned laser beam scan in the direction of X on a workpiece in invention of claim 1, and the direction of Y, and the above-mentioned amendment means is characterized by the thing of the above-mentioned X scanner or Y scanner for which one of drives are controlled at least according to the gap direction of the optical axis of the laser beam by the above-mentioned optical attenuating means.

[0016] If according to invention of claim 1 thru/or claim 3 angle of rotation of an optical attenuating means is changed in order to change the reinforcement of a laser beam, the shift amount of the optical axis of a laser beam is computed from the angle of rotation, and since the amount of gaps of the exposure location of the laser beam which irradiates a workpiece according to the calculation value is amended, even if it controls the reinforcement of a laser beam by the optical attenuating means, it can prevent that process tolerance falls.

[0017]

[Embodiment of the Invention] Hereafter, the gestalt of implementation of this invention is explained with reference to a drawing. Drawing 1 thru/or drawing 4 show the gestalt of implementation of the 1st of this invention, and drawing 1 is fiber branch-type Leh Zama-king equipment as laser-processing equipment. This Leh Zama-king equipment is equipped with the laser oscillation machines 11, such as an YAG laser. Incidence of the laser beam L by which the oscillation output was carried out from this laser oscillation machine 11 is carried out to the fiber branching switch section 12, and it is divided into two or more laser beam L. Laser beam L is divided into two with the gestalt of this operation.

[0018] It is condensed with the incidence lens 13 and incidence of the laser beam L divided in the above-mentioned fiber branching switch section 12 is carried out to an optical fiber 14, respectively. Incidence of the outgoing radiation edge of each optical fiber 14 is carried out to the optical head 15.

[0019] The above-mentioned optical head 15 has the collimate lens 16 which changes into parallel light laser beam L which carried out outgoing radiation from the optical fiber 14 from emission light as shown in drawing 2. Incidence of the laser beam L changed into parallel light with this collimate lens 16 is carried out to the optical attenuation plate 17 formed free [ rotation ].

[0020] By drive control of the angle of rotation being carried out, adjusting angle of rotation, and changing whenever [ incident angle / of laser beam L ] by the 1st driving source 18, since the above-mentioned optical attenuation plate 17 changes the permeability of laser beam L which carries out outgoing radiation from this optical attenuation plate 17, it can adjust the reinforcement of that laser beam L.

[0021] After the reinforcement is detected by the power monitor 19, incidence of the laser beam L to which reinforcement was adjusted with the above-mentioned optical attenuation plate 17 is carried out to the deviation mirror 20. This deviation mirror 20 can change now the reflective direction (the direction of outgoing radiation) of laser beam L which had come to be able to carry out include-angle adjustment by the 2nd driving source 21, and carried out incidence to this deviation mirror 20 by it.

[0022] Incidence of the laser beam L reflected by the above-mentioned deviation mirror 20 is carried out to a condenser lens 22, it converges with this condenser lens 22, and irradiates a workpiece 23. This workpiece 23 is laid on X-Y table 24, and can set up now the exposure location of the above-mentioned laser beam L.

[0023] The reinforcement of laser beam L detected by the above-mentioned power monitor 19 is inputted into a control unit 25. This control unit 25 can set up now the set point A for setting up the reinforcement of laser beam L, compares that set point A with the detection value from the above-mentioned power monitor 19, outputs a driving signal to the 1st driving source 18 based on that comparison, and controls the include angle of the above-mentioned optical attenuation plate 17.

[0024] The include angle of the above-mentioned optical attenuation plate 17 is controlled by it so that the reinforcement of laser beam L detected by the power monitor 19 and the set point set as the control unit 25 are in agreement.

[0025] The above-mentioned control unit 25 detects angle of rotation of the above-mentioned optical attenuation plate 17 with the driving signal which drives the 1st driving source 18, and it computes it so that the shift amount of the optical axis which changes because the above-mentioned laser beam L passes the optical attenuation plate 17 from the detecting signal may be mentioned later. And the include angle of the above-mentioned deviation mirror 19 by the 2nd driving source 21 of the above is controlled from the shift amount of this optical axis, and a gap of laser beam L which converges with a condenser lens 22 and irradiates a workpiece 23 is amended.

[0026] Data processing of the amendment of the amount of gaps of the location where laser beam L by the above-mentioned control unit 25 irradiates a workpiece 23 is carried out as the following. It is whenever [ incident angle / of laser beam L / as opposed to / as shown in drawing 3 / the optical attenuation plate 17 ] theta 1 It carries out and is angle of refraction

theta 2 When it carries out, shift-amount  $d$  of the optical axis of laser beam  $L$   $d=t \cdot \sin(\theta_1) / \cos(\theta_2)$  -- (1) Formula It can ask and is a Snell's law.  $\sin(\theta_1) = n \cdot \sin(\theta_2)$  It is -- (2) type. In addition, in the above (1) and (2) types,  $t$  is the thickness of the optical attenuation plate 17, and  $n$  is a refractive index.

[0027] The amount  $dx$  of gaps of laser beam  $L$  in the processing side of a workpiece 23 when shift-amount  $d$  shown in an optical axis at the above-mentioned (1) formula arises on the other hand because laser beam  $L$  penetrates the optical attenuation plate 17  $dx=df$  and  $d/f$  -- (3) It is shown by the formula. In addition, the inside  $f$  of a formula is the focal location of a condenser lens 22, and  $df$ . It is the amount of defocusing.

[0028] The amount  $dx$  of gaps of laser beam  $L$  in the processing side of a workpiece 23 It is  $\theta_{M1}$  about angle of rotation of the deviation mirror 20 required in order to amend. If it carries out, it is the amount  $dx$  of gaps in respect of processing.  $dx=(f+df) \cdot \theta_{M1}$  and 2 -- (4) It becomes a formula.

[0029] The above-mentioned (3) formula and (4) types  $\theta_{M1}=df$  and  $d/[2f-(f+df)]$  -- (5) Formula It is becoming and combining this (5) type with (1) type.  $\theta_{M1}=df$  and  $t \cdot \sin(\theta_1) / [2f-(f+df)] \cdot \cos(\theta_2)$  -- (6) It becomes a formula.

[0030] Therefore, the amount  $dx$  of gaps of shift-amount  $d$  of the optical axis of laser beam  $L$  according by this (6) type to the angle of rotation  $\theta_1$  (whenever [ incident angle / of laser beam  $L$  ]  $\theta_1$ ) of the optical attenuation plate 17, and laser beam  $L$  in a processing point Angle-of-rotation  $\theta_{M1}$  of the deviation mirror 20 for amending Relation is determined.

[0031] the exposure location of laser beam  $L$  on the processing side of a workpiece 23 -- the above-mentioned (6) formula -- being based -- angle-of-rotation  $\theta_{M1}$  of the deviation mirror 20 although you may control, if the amount  $dx$  of gaps in respect of processing is computed -- the exposure location of laser beam  $L$  -- the above-mentioned amount  $dx$  of gaps only -- you may make it position a workpiece 23 by X-Y table 24 so that it may be amended

[0032] And it does in this way and is angle-of-rotation  $\theta_{M1}$ . If computed, it is the directions electrical potential difference  $V$  to the 2nd driving source 21.  $V=f \cdot \theta_{M1}$  -- (7) A formula is determined. In addition,  $f$  is angle-of-rotation  $\theta_{M1}$  of the deviation mirror 20. It is the function which shows relation with the directions electrical potential difference  $V$ .

[0033] Below, the laser-processing equipment of the above-mentioned configuration explains the procedure in the case of carrying out laser processing of the workpiece 23 with reference to drawing 4. First, in S1, the exposure location of laser beam  $L$  to the reinforcement of laser beam  $L$  and a workpiece 23 (step 1) is set up by the control unit 25. A workpiece 23 is positioned by X-Y table 24 by it in a predetermined location. From the laser oscillation machine 11, the predetermined pulse number oscillation of the laser beam  $L$  is carried out, and the reinforcement is detected with the power monitor 19 by it and coincidence. It is this S2 It is shown.

[0034] S3 It is S4, if the reinforcement and the set point  $A$  of laser beam  $L$  which the power monitor 19 detected with the control unit 25 then are compared and the reinforcement of laser beam  $L$  has not become the set point  $A$ . To be shown, a driving signal is outputted to the 1st driving source 18 from a control unit 25, and the include angle of the optical attenuation plate 17 is controlled.

[0035] It is S5 when the reinforcement of laser beam  $L$  which the power monitor 19 detects becomes the same value as the set point  $A$ . Optical-axis shift-amount  $d$  of laser beam  $L$  produced with angle of rotation of the optical attenuation plate 17 so that it may be shown is computed based on the above-mentioned (1) formula. Subsequently, the above-mentioned control unit 25 is the amount  $dx$  of gaps of laser beam  $L$  produced in respect of processing of a workpiece 23 by optical-axis shift-amount  $d$ . Angle-of-rotation  $\theta_{M1}$  of the deviation mirror 20 required in order to amend It computes based on the above-mentioned (6) formula. It is this S6 It is shown.

[0036] S6 Angle-of-rotation  $\theta_{M1}$  of the deviation mirror 20 It will be S7 if computed. In order to set up the include angle of above-mentioned deviation \*\* 20 according to the calculation value so that it may be shown, the electrical-potential-difference value outputted to the 2nd driving source 21 is set up based on the above-mentioned (7) formula.

[0037] Thus, it is S8 when the directions electrical potential difference  $V$  for setting up the include angle of the deviation mirror 29 is set up. Laser processing is then started. it — S9 \*\*\*\* — since the driving signal of the directions electrical potential difference  $V$  is outputted to the 2nd driving source 21 from a control unit 25 and the include angle of the deviation mirror 29 is set up, the shift amount of the optical axis of laser beam  $L$  with the optical attenuation plate 17 is amended, and a workpiece 23 is irradiated. By it, to a workpiece 23, since laser processing, such as marking, can be performed to a position at a precision, as shown in S10, laser processing is completed.

[0038] In performing laser processing not using two optical heads 15 by laser beam  $L$  of reinforcement which is different in the location where the above-mentioned workpiece 23 changes with one optical heads 15, it carries out the setting input of the reinforcement and the exposure location of laser beam  $L$  in two or more processing points at a control unit 25. S2 mentioned above by it from — by the process of S10 being performed, as laser processing to the location where the above-mentioned workpieces 23 differ was mentioned above, it is high degree of accuracy, and since the include angle of the optical attenuation plate 17 is moreover changed and the reinforcement of laser beam  $L$  is controlled, it can carry out by being high-speed.

[0039] It is angle-of-rotation  $\theta_M$  of the deviation mirror 20 about amendment of the processing location according to laser beam  $L$  on the other hand. It is S5 when X-Y table 24 in which the workpiece 23 was laid performs without amending. The amount  $dx$  of gaps of laser beam [ if optical-axis shift-amount  $d$  of laser beam  $L$  is computed, are based on (3) types from optical-axis shift-amount  $d$ , and / on a workpiece 23 ]  $L$  It computes. And this amount  $dx$  of gaps It is based, X-Y table 24 is driven, and a workpiece 23 is positioned.

[0040] That is, the above-mentioned workpiece 23 is positioned so that laser beam  $L$  which carries out outgoing radiation from the above-mentioned optical head 15 may irradiate the processing point that the above-mentioned workpiece 23 was set up. Even if it does not control the include angle of the deviation mirror 20 by it, it is high-speed with a sufficient precision, and processing by laser beam  $L$  can be performed by it.

[0041] On the other hand, the above-mentioned laser-processing equipment is equipped with two optical heads 15. Therefore, two optical heads 15 can be used together and laser processing can also be performed to a workpiece 23. In that case, since what is necessary is just to make a sequential change of the include angle of the optical attenuation plate 17 of the optical head 15 of a pair in order to carry out laser processing by laser beam  $L$  of different reinforcement to two or more processing points, compared with the case where two or more processing points with one optical head 5 are processed by laser beam  $L$  of different reinforcement, the switch rate of angle of rotation of the optical attenuation plate 17 can be made loose.

[0042] Drawing 5 shows the gestalt of implementation of the 2nd of this invention. Hereafter, it explains with reference to this drawing. In addition, the same notation is given to the same part as the gestalt of the 1st operation shown in drawing 1, and explanation is omitted.

[0043] That is, the gestalt of this operation is laser-processing equipment which laser beam  $L$  is made to scan in the direction of  $X$ , and the direction of  $Y$ , and carries out marking to a workpiece 23 in the way of a picture drawn without lifting the brush from the paper, and this laser-processing equipment is equipped with the laser oscillation machine 11. The optical attenuation plate 17 with which angle of rotation is set up by the 1st driving source 18 is arranged by the optical path of laser beam  $L$  outputted from this laser oscillation machine 11. With this optical attenuation plate 17, laser beam  $L$  to which reinforcement was set passes the power monitor 19, and it carries out incidence to the  $X$  scanner 31. Incidence of the laser beam  $L$  which carried out outgoing radiation from this  $X$  scanner 31 is carried out to the  $Y$  scanner 32, subsequently it carries out outgoing radiation from this  $Y$  scanner 32, converges with a condenser lens 33, and irradiates the workpiece 23 laid on X-Y table 24.

[0044] Drive control of  $X$  driving source 31a of the 1st driving source 18 of the above and the above-mentioned  $X$  scanner 31 and the  $Y$  driving source 32a of the  $Y$  scanner 32 is carried out by the control unit 34.

[0045] That is, if the 1st driving source 18 is driven and angle of rotation of the optical



attenuation plate 17 is set up like the gestalt of implementation of the above 1st in order to set up the reinforcement of laser beam L, angle of rotation of the optical attenuation plate 17 by the 1st driving source 18 of the above will be called for. It is  $\theta_1$  whenever [ incident angle / of laser beam L to the above-mentioned optical attenuation plate 17 from this angle of rotation ]. Angle of refraction  $\theta_2$  of the optical attenuation plate 17 which is known since it asks The amount d of gaps of the optical axis of laser beam L is computed based on the above-mentioned (1) formula.

[0046] The amount dx of gaps of laser beam [ if the amount d of gaps of an optical axis can be found, are based on the above-mentioned (3) formula, and / on a workpiece 23 ] L Angle-of-rotation  $\theta_M$  which requires amendment based on the above-mentioned (5) formula and (6) types from this calculation value since it is computed It can ask.

[0047] If the gap direction of the optical axis of laser beam L is the direction of X, it is angle-of-rotation  $\theta_M$ . If it is based, the drive of the X scanner 31 is amended and the gap direction of an optical axis is the direction of Y, it is angle-of-rotation  $\theta_M$ . It is based and the drive of the Y scanner 32 is amended. When having shifted to the both sides of the direction of X, and the direction of Y, the both sides of the X scanner 31 and the Y scanner 32 are amended.

[0048] It can perform marking which makes laser beam L scan in the direction of X, and the direction of Y on a workpiece 23 with high precision. Also in the gestalt of this operation, the X scanner 31 or the Y scanner 32 does not perform amendment accompanying a gap of the optical axis of laser beam L, but it may be made to perform it by X-Y table 24 in which the workpiece 23 was laid.

[0049] This invention is applicable if this invention not being limited to the gestalt of each above-mentioned implementation, and not being limited to marking equipment as laser-processing equipment, for example, processing it by changing the reinforcement of laser beams, such as cutting equipment, hole dawn equipment, and a thermal treatment equipment, is laser-processing equipment demanded.

[0050]

[Effect of the Invention] In order to change the reinforcement of a laser beam, when angle of rotation of an optical attenuating means was changed according to invention of claim 1 thru/or claim 3, the amount of gaps of the optical axis of a laser beam is computed from the angle of rotation, the exposure location of the laser beam which irradiates a workpiece according to the calculation value is amended, and it was made to irradiate.

[0051] Therefore, since the exposure location of the workpiece by the laser beam can be set up with high precision even if an optical-axis shift arises by using an optical attenuating means, in order to process a workpiece by the laser beam of different reinforcement, it can prevent that process tolerance falls.

[0052] In order to amend an optical-axis shift, it does not necessarily become impossible and for a loss to arise in a laser beam or for the reinforcement of the laser beam in a processing point to set it as it correctly like [ at the time of using an optical-path corrector plate ], by change of the permeability by the include angle of this optical-path corrector plate.

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] The rough block diagram of the laser-processing equipment in which the gestalt of implementation of the 1st of this invention is shown.

[Drawing 2] The block diagram of the optical head into which a laser beam is similarly introduced with an optical fiber.

[Drawing 3] An explanatory view with the amount of gaps of the optical-axis shift of the laser beam similarly according to an optical attenuation plate, and the exposure location on a workpiece.

[Drawing 4] The flow chart which similarly shows the procedure of laser processing.

[Drawing 5] The rough block diagram of the laser-processing equipment in which the gestalt of implementation of the 2nd of this invention is shown.

[Drawing 6] The block diagram of conventional laser-processing equipment.

[Drawing 7] The block diagram of other conventional laser-processing equipments.

[Description of Notations]

11 -- Laser oscillation machine

17 -- Optical attenuation plate (optical attenuating means)

18 -- The 1st driving source

20 -- Deviation mirror

21 -- The 2nd driving source

24 -- X-Y table (amendment means)

25 34 -- Control unit (amendment means)

31 -- X scanner

32 -- Y scanner

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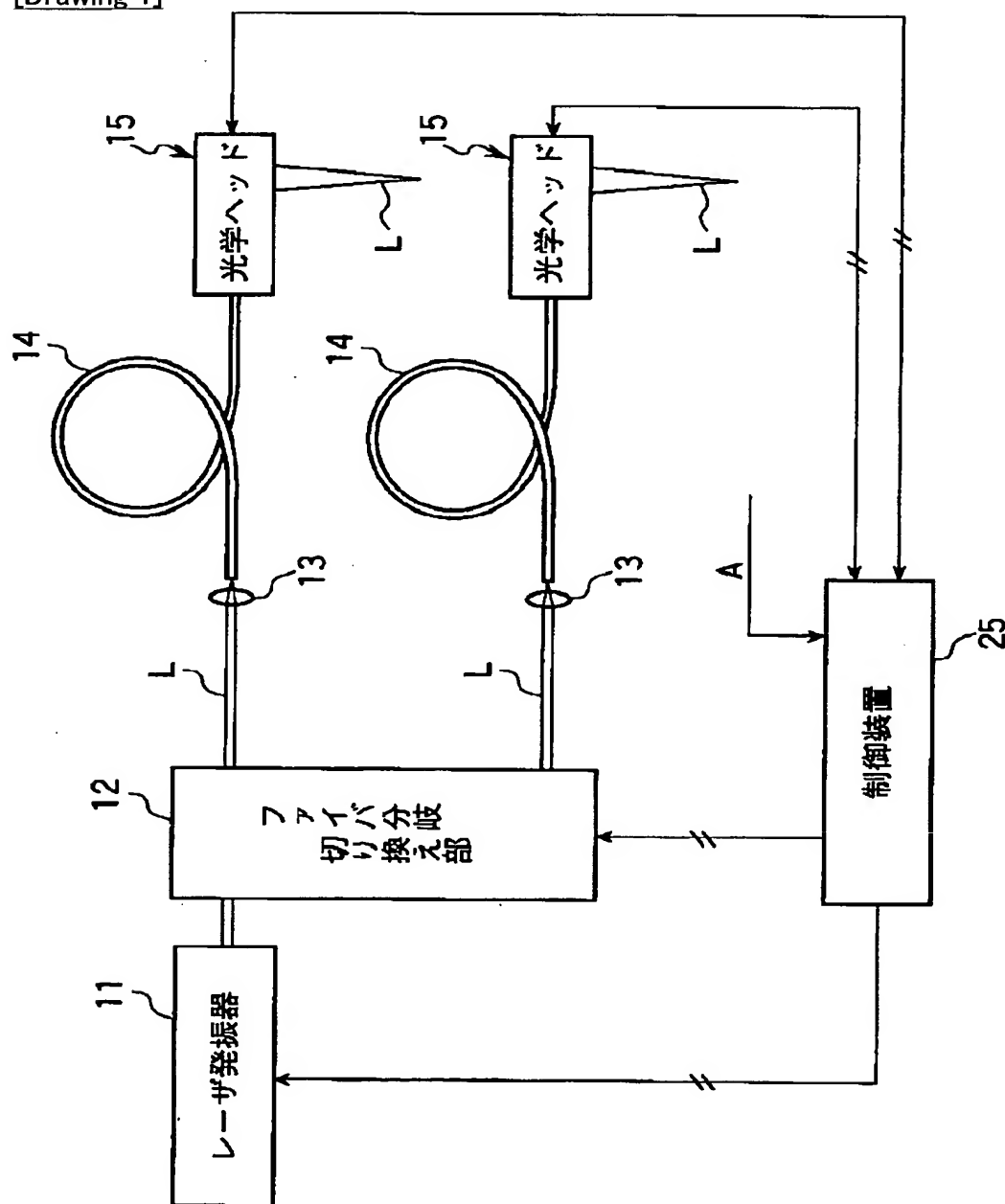
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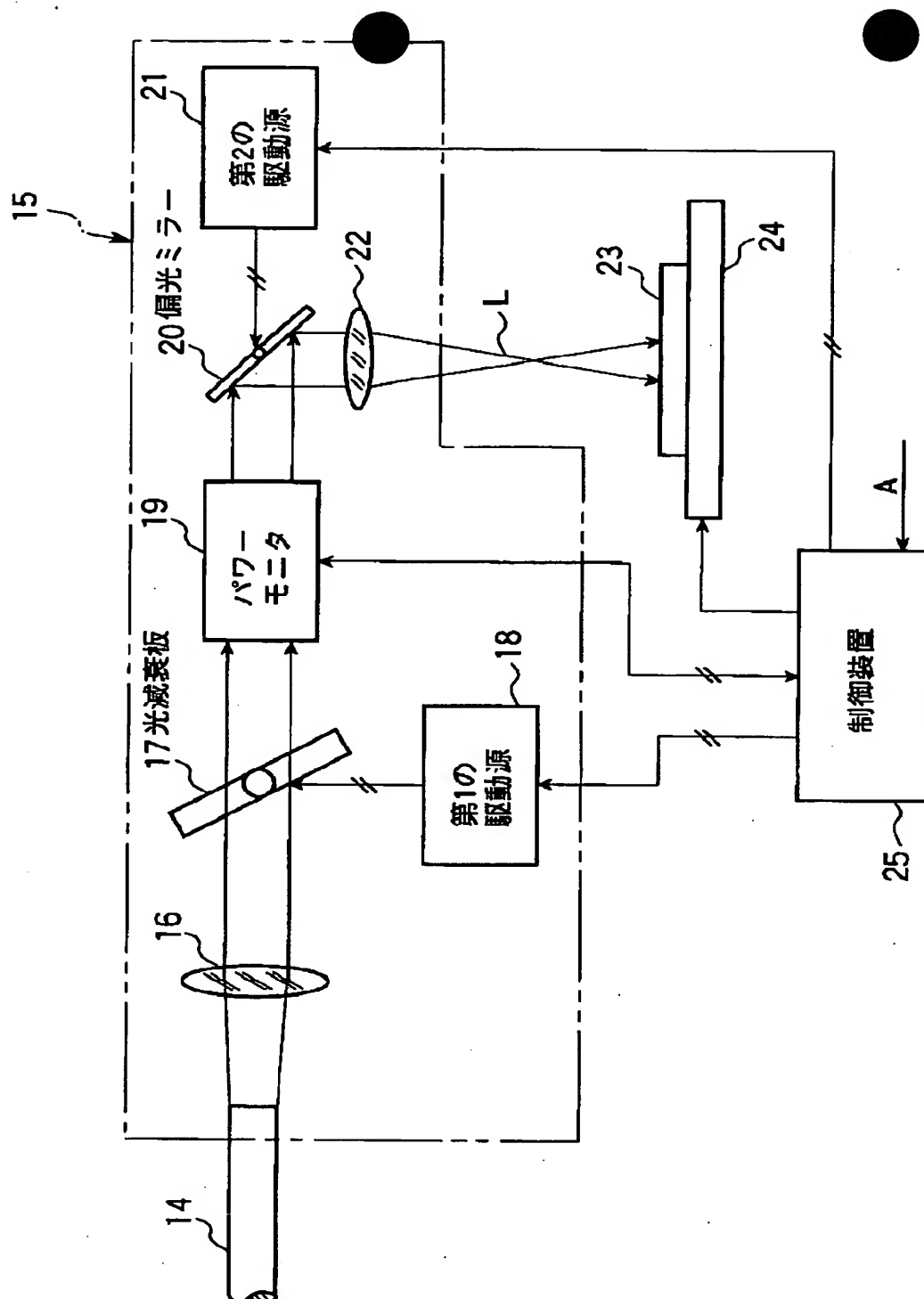
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## DRAWINGS

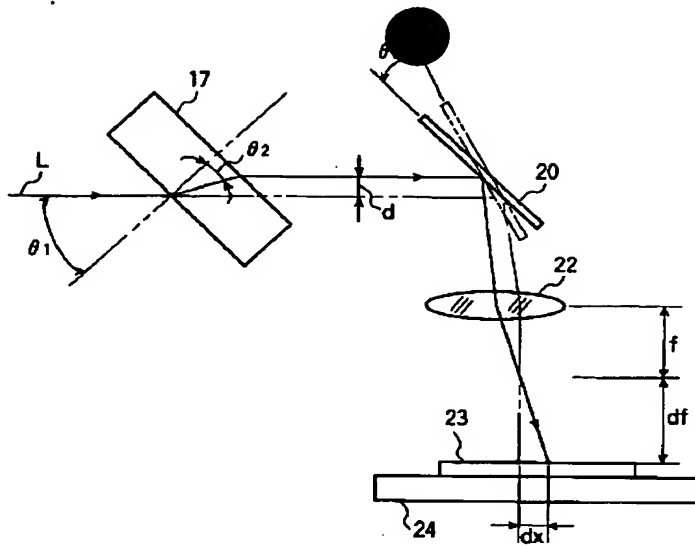
[Drawing 1]



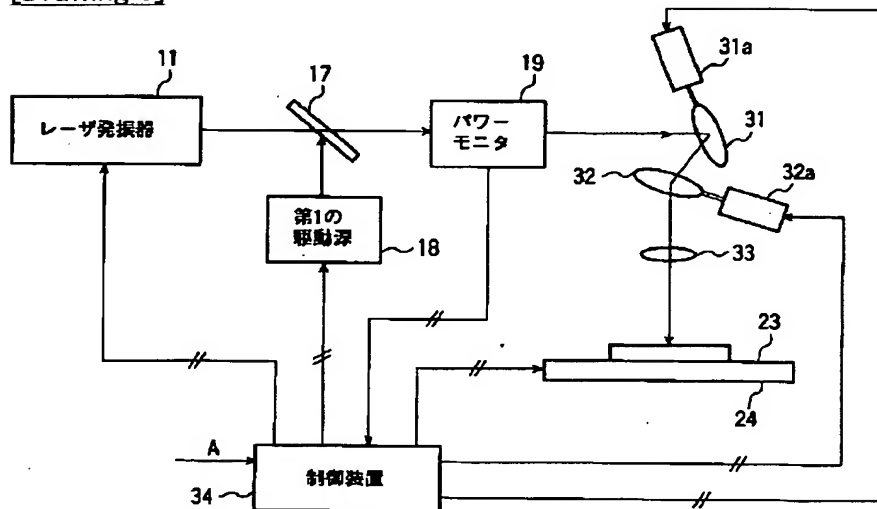
[Drawing 2]



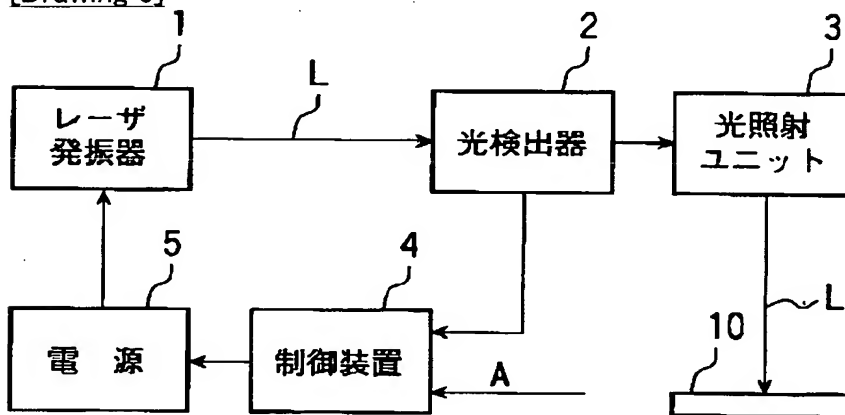
[Drawing 3]



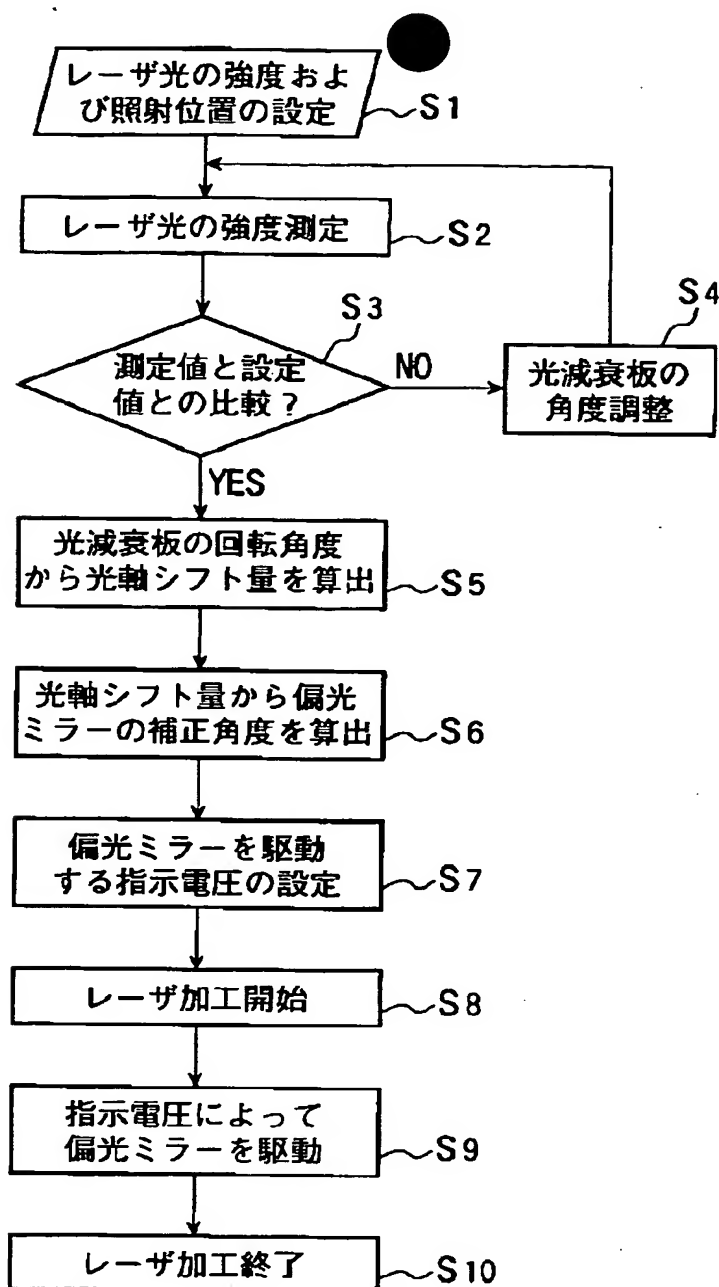
[Drawing 5]



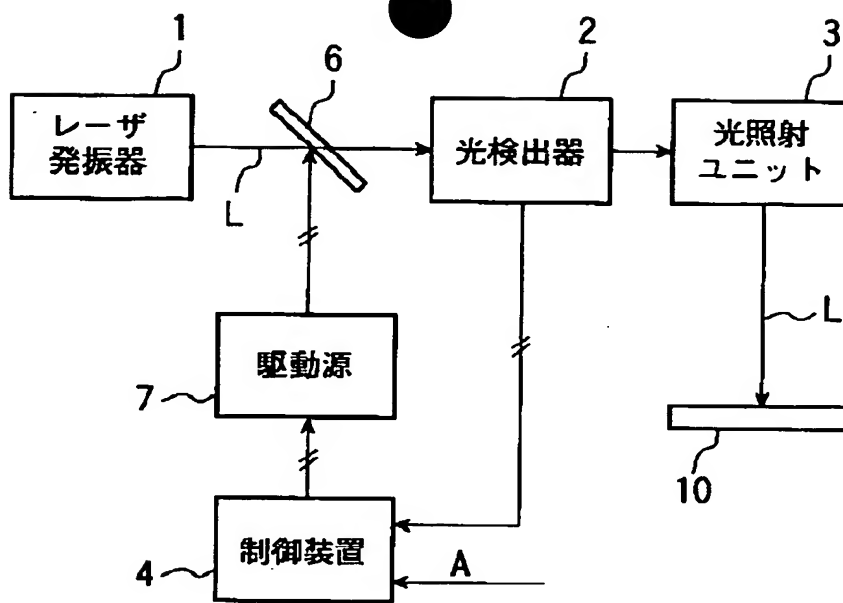
[Drawing 6]



[Drawing 4]



[Drawing 7]



[Translation done.]





**【特許請求の範囲】**

**【請求項1】** 被加工物にレーザ光を照射してレーザ加工するレーザ加工装置において、

上記レーザ光を出力するレーザ発振器と、

回転角度の調整可能に設けられ上記レーザ光の入射角度を変えることで出射するレーザ光の強度を制御する光減衰手段と、

この光減衰手段によって強度が制御されたレーザ光を上記被加工物に照射する光照射手段と、

上記光減衰手段の回転角度を検出しその回転角度に応じて上記光減衰手段で生じる上記レーザ光の光軸のずれ量を算出し、その算出値によって上記光照射手段を制御して被加工物を照射するレーザ光の照射位置を補正する補正手段とを具備したことを特徴とするレーザ加工装置。

**【請求項2】** 上記光照射手段は、上記レーザ光の方向を偏向する偏向ミラーと、この偏向ミラーの角度を変える駆動手段と、上記偏向ミラーで反射したレーザ光を集束する光学レンズとからなり、

上記補正手段は上記偏向ミラーの角度を制御することを特徴とする請求項1または請求項2記載のレーザ加工装置。

**【請求項3】** 上記光照射手段は、上記レーザ光を被加工物上でX方向に走査させるXスキャナと、Y方向に走査させるYスキャナとからなり、

上記補正手段は上記光減衰手段によるレーザ光の光軸のずれ方向に応じて上記XスキャナあるいはYスキャナの少なくともどちらか一方の駆動を制御することを特徴とする請求項1または請求項2記載のレーザ加工装置。

**【発明の詳細な説明】****【0001】**

**【発明の属する技術分野】** この発明はレーザ光を所望の強度に調整して被加工物を加工するレーザ加工装置に関する。

**【0002】**

**【従来の技術】** レーザ光によって被加工物を加工するレーザ加工装置においては、複数の加工点を異なる強度のレーザ光で加工することが要求されることがある。図6はそのような場合の従来のレーザ加工装置を示す。同図中1はたとえばYAGレーザなどのレーザ発振器で、このレーザ発振器1から出力されたレーザ光Lは、そのレーザ光Lの強度を検出する光検出器2を通過して光照射ユニット3に入射する。この光照射ユニット3は図示しないが偏向ミラーや光学レンズなどが内蔵されていて、ここに入射したレーザ光Lを集束して被加工物10を照射するようになっている。

**【0003】** 上記光検出器2からの検出信号は制御装置4に入力される。この制御装置4は設定値Aと検出値とを比較し、その比較に応じて上記レーザ発振器1を励起する電源5による電流値を制御する。それによって、レーザ発振器1からのレーザ光Lの強度を上記制御装置4

に設定された設定値に変えることができるようにしている。

**【0004】** しかしながら、このようにしてレーザ光Lの強度を制御すると、電源5の電流値を変えてからレーザ発振器1から発振されるレーザ光Lの出力が設定値になるまでに数秒単位の時間が掛かる。そのため、被加工物10の加工点を高速（ms単位の速度）で変えることができないから、加工能率を向上させることができないということがある。

**【0005】** そこで、レーザ光Lの出力を高速で変えることができるようにするため、図7に示す光減衰板6が用いられている。この光減衰板6はレーザ発振器1と光検出器2との間に設けられ、駆動源7によってレーザ光Lの光軸に対する傾斜角度、つまりレーザ光Lの入射角度を変えることができるようになっている。

**【0006】** 光減衰板6に対するレーザ光Lの入射角度が変わることで、この光減衰板6から出射するレーザ光Lの減衰率が変わる。したがって、光検出器2が検出するレーザ光Lの強度に応じて駆動源7により上記光減衰板6の角度を制御することで、レーザ光Lの強度を変えることができる。

**【0007】** 光減衰板6の角度を制御するようにすれば、図6のようにレーザ発振器1の電源5の電流値を変えてレーザ光Lの強度を制御する場合に比べ応答速度を速くすることができるから、加工点を高速で変えることが可能となる。

**【0008】** しかしながら、光減衰板6から出射するレーザ光Lは、この光減衰板6の屈折率に応じて光軸がシフトする。そのため、光減衰板6から出射し、光照射ユニット3で集束されて被加工物10を照射するレーザ光Lの照射位置がずれ、加工精度が低下するということがある。

**【0009】** 光減衰板6による光軸シフトを補正するために、光減衰板6と鏡対象面に光路補正板を設け、これらを同期させて駆動することが考えられる。しかしながら、光路補正板はレーザ光の透過ロスを少なくするために両面に反射防止コートが施される。反射防止コートの透過率はレーザ光Lの入射角度によって異なる。

**【0010】** そのため、この光路補正板によってレーザ光Lの透過ロスの生じるばかりか、被加工物10を照射するレーザ光Lの強度を正確に設定できなくなるということがある。

**【0011】**

**【発明が解決しようとする課題】** このように、光減衰板を用いてレーザ光の強度を制御すると、強度の切り換えは高速で行えるものの、レーザ光が上記光減衰板で屈折することで光軸がずれるため、加工精度が低下するということが生じる。

**【0012】** この発明は、レーザ光の強度を光減衰手段を用いて制御するようにした場合、この光減衰手段によ

ってレーザ光の光軸がずれても、そのずれを補正して被加工物を照射できるようにしたレーザ加工装置を提供することにある。

#### 【0013】

【課題を解決するための手段】請求項1の発明は、被加工物にレーザ光を照射してレーザ加工するレーザ加工装置において、上記レーザ光を出力するレーザ発振器と、回転角度の調整可能に設けられ上記レーザ光の入射角度を変えることで出射するレーザ光の強度を制御する光減衰手段と、この光減衰手段によって強度が制御されたレーザ光を上記被加工物に照射する光照射手段と、上記光減衰手段の回転角度を検出しその回転角度に応じて上記光減衰手段で生じる上記レーザ光の光軸のずれ量を算出し、その算出値によって上記光照射手段を制御して被加工物を照射するレーザ光の照射位置を補正する補正手段とを具備したことを特徴とする。

【0014】請求項2の発明は、請求項1の発明において、上記光照射手段は、上記レーザ光の方向を偏向する偏向ミラーと、この偏向ミラーの角度を変える駆動手段と、上記偏向ミラーで反射したレーザ光を集束する光学レンズとからなり、上記補正手段は上記偏向ミラーの角度を制御することを特徴とする。

【0015】請求項3の発明は、請求項1の発明において、上記光照射手段は、上記レーザ光を被加工物上でX方向に走査させるXスキャナと、Y方向に走査させるYスキャナとからなり、上記補正手段は上記光減衰手段によるレーザ光の光軸のずれ方向に応じて上記XスキャナあるいはYスキャナの少なくともどちらか一方の駆動を制御することを特徴とする。

【0016】請求項1乃至請求項3の発明によれば、レーザ光の強度を変えるために光減衰手段の回転角度を変えると、その回転角度からレーザ光の光軸のシフト量が算出され、その算出値に応じて被加工物を照射するレーザ光の照射位置のずれ量が補正されるから、光減衰手段によってレーザ光の強度を制御するようにしても、加工精度が低下するのを防止できる。

#### 【0017】

【発明の実施の形態】以下、この発明の実施の形態を図面を参照して説明する。図1乃至図4はこの発明の第1の実施の形態を示し、図1はレーザ加工装置としてのファイバ分岐型レーザマーキング装置である。このレーザマーキング装置はYAGレーザなどのレーザ発振器11を備えている。このレーザ発振器11から発振出力されたレーザ光Lはファイバ分岐切り換え部12に入射して、複数のレーザ光Lに分割される。この実施の形態ではレーザ光Lは2つに分割される。

【0018】上記ファイバ分岐切り換え部12で分割されたレーザ光Lはそれぞれ入射レンズ13で集光されて光ファイバ14に入射する。各光ファイバ14の出射端

は光学ヘッド15に入射する。

【0019】上記光学ヘッド15は、図2に示すように光ファイバ14から出射したレーザ光Lを発散光から平行光に変換するコリメートレンズ16を有する。このコリメートレンズ16で平行光に変換されたレーザ光Lは回転自在に設けられた光減衰板17に入射する。

【0020】上記光減衰板17は第1の駆動源18によって回転角度が駆動制御されるようになっていて、回転角度を調整してレーザ光Lの入射角度を変えることで、この光減衰板17から出射するレーザ光Lの透過率が変わるから、そのレーザ光Lの強度を調整できるようになっている。

【0021】上記光減衰板17で強度が調整されたレーザ光Lはパワーモニタ19によってその強度が検出されてから偏向ミラー20に入射する。この偏向ミラー20は第2の駆動源21によって角度調整できるようになっており、それによってこの偏向ミラー20に入射したレーザ光Lの反射方向（出射方向）を変えることができるようになっている。

【0022】上記偏向ミラー20で反射したレーザ光Lは集光レンズ22に入射し、この集光レンズ22で集束されて被加工物23を照射するようになっている。この被加工物23はXYテーブル24上に載置され、上記レーザ光Lの照射位置を設定できるようになっている。

【0023】上記パワーモニタ19によって検出されたレーザ光Lの強度は制御装置25に入力される。この制御装置25はレーザ光Lの強度を設定するための設定値Aを設定できるようになっていて、その設定値Aと上記パワーモニタ19からの検出値とを比較し、その比較に基づいて第1の駆動源18に駆動信号を出力し、上記光減衰板17の角度を制御するようになっている。

【0024】それによって、パワーモニタ19により検出されたレーザ光Lの強度と、制御装置25に設定された設定値とが一致するよう、上記光減衰板17の角度が制御される。

【0025】上記制御装置25は、第1の駆動源18を駆動する駆動信号によって上記光減衰板17の回転角度を検出し、その検出信号から上記レーザ光Lが光減衰板17を通過することで変化する光軸のシフト量を後述するごとく算出する。そして、この光軸のシフト量から上記第2の駆動源21による上記偏向ミラー19の角度を制御し、集光レンズ22で集束されて被加工物23を照射するレーザ光Lのずれを補正するようになっている。

【0026】上記制御装置25によるレーザ光Lが被加工物23を照射する位置のずれ量の補正は以下のごとく演算処理される。図3に示すように、光減衰板17に対するレーザ光Lの入射角度を $\theta_1$ とし、屈折角を $\theta_2$ とすると、レーザ光Lの光軸のシフト量dは、

$$d = t \cdot \sin(\theta_1 \cdot \theta_2) / \cos(\theta_2) \quad \dots (1) \text{式}$$

で求めることができ、またスネルの法則より、

$$\sin(\theta_1) = n \cdot \sin(\theta_2)$$

…(2)式

である。なお、上記(1)、(2)式において、 $t$ は光減衰板17の厚さであり、 $n$ は屈折率である。

【0027】一方、レーザ光Lが光減衰板17を透過す

$$dx = df \cdot d / f$$

で示される。なお、式中 $f$ は集光レンズ22の焦点位置、 $df$ はディフォーカス量である。

【0028】被加工物23の加工面におけるレーザ光L

$$dx = (f + df) \cdot \theta_H \cdot 2$$

…(4)式

となる。

$$\theta_H = df \cdot d / \{2f \cdot (f + df)\}$$

…(5)式

となり、この(5)式を(1)式と組み合わせることで、

$$\theta_H = df \cdot t \cdot \sin(\theta_1 \cdot \theta_2) / \{2f \cdot (f + df) \cdot \cos(\theta_2)\}$$

…(6)式

となる。

【0030】したがって、この(6)式により、光減衰板17の回転角度 $\theta_1$ （レーザ光Lの入射角度 $\theta_1$ ）によるレーザ光Lの光軸のシフト量 $d$ と、加工点におけるレーザ光Lのずれ量 $dx$ を補正するための偏向ミラー20の回転角度 $\theta_H$ との関係が決定される。

【0031】被加工物23の加工面上におけるレーザ光

$$V = f \cdot (\theta_H)$$

によって決定される。なお、 $f$ は偏向ミラー20の回転角度 $\theta_H$ と指示電圧 $V$ との関係を示す関数である。

【0033】つぎに、上記構成のレーザ加工装置によって被加工物23をレーザ加工する場合の手順を図4を参照して説明する。まず、S1（ステップ1）では制御装置25によってレーザ光Lの強度と被加工物23に対するレーザ光Lの照射位置とが設定される。それによって、被加工物23はXYテーブル24によって所定位置に位置決めされる。それと同時に、レーザ発振器11からはレーザ光Lが所定パルス数発振され、その強度がパワーモニタ19によって検出される。これをS2に示す。

【0034】S3では、制御装置25によってパワーモニタ19が検出したレーザ光Lの強度と設定値Aとが比較され、レーザ光Lの強度が設定値Aになっていなければ、S4で示すように、制御装置25から第1の駆動源18に駆動信号が出力されて光減衰板17の角度が制御される。

【0035】パワーモニタ19が検出するレーザ光Lの強度が設定値Aと同じ値になると、S5に示すように光減衰板17の回転角度によって生じるレーザ光Lの光軸シフト量 $d$ が上記(1)式に基いて算出される。ついで、上記制御装置25は光軸シフト量 $d$ により被加工物23の加工面で生じるレーザ光Lのずれ量 $dx$ を補正するために必要な偏向ミラー20の回転角度 $\theta_H$ を上記(6)式に基いて算出する。これをS6に示す。

【0036】S6にて偏向ミラー20の回転角度 $\theta_H$ が

ることで、光軸に上記(1)式に示すシフト量 $d$ が生じた場合、被加工物23の加工面におけるレーザ光Lのずれ量 $dx$ は、

…(3)式

のずれ量 $dx$ を補正するために必要な偏向ミラー20の回転角度を $\theta_H$ とすると、加工面でのずれ量 $dx$ は、

【0029】上記(3)式と(4)式より、

Lの照射位置は、上記(6)式に基いて偏向ミラー20の回転角度 $\theta_H$ を制御してもよいが、加工面でのずれ量 $dx$ を算出したら、レーザ光Lの照射位置が上記ずれ量 $dx$ だけ補正されるよう、被加工物23をXYテーブル24によって位置決めするようにしてもよい。

【0032】そして、このようにして回転角度 $\theta_H$ が算出されると、第2の駆動源21への指示電圧 $V$ は、

…(7)式

算出されたならば、S7に示すようにその算出値に応じて上記偏向ミラー20の角度を設定するために第2の駆動源21に出力される電圧値が上記(7)式に基いて設定される。

【0037】このようにして偏向ミラー29の角度を設定するための指示電圧 $V$ が設定されると、S8ではレーザ加工が開始される。それによって、S9では制御装置25から第2の駆動源21へ指示電圧 $V$ の駆動信号が出力され、偏向ミラー29の角度が設定されるから、光減衰板17によるレーザ光Lの光軸のシフト量が補正されて被加工物23を照射する。それによって、被加工物23には、所定の位置に精密にマーキングなどのレーザ加工を行うことができるから、S10で示すようにレーザ加工が終了する。

【0038】2つの光学ヘッド15を用いず、1つの光学ヘッド15によって上記被加工物23の異なる位置に異なる強度のレーザ光Lでレーザ加工を行う場合には、制御装置25に複数の加工点におけるレーザ光Lの強度および照射位置を設定入力する。それによって、上述したS2からS10の工程が行われることで、上記被加工物23の異なる位置に対するレーザ加工を、上述したごとく高精度で、しかも光減衰板17の角度を変えてレーザ光Lの強度を制御するため、高速度で行うことができる。

【0039】一方、レーザ光Lによる加工位置の補正を、偏向ミラー20の回転角度 $\theta_H$ を補正せずに、被加工物23が載置されたXYテーブル24によって行う場

合、S5でレーザ光Lの光軸シフト量dを算出したならば、その光軸シフト量dから(3)式に基いて被加工物23上におけるレーザ光Lのずれ量dxを算出する。そして、このずれ量dxに基いてXYテーブル24を駆動して被加工物23を位置決めする。

【0040】つまり、上記光学ヘッド15から出射するレーザ光Lが上記被加工物23の設定された加工点を照射するよう、上記被加工物23が位置決めされる。それによって、偏向ミラー20の角度を制御しなくとも、レーザ光Lによる加工を精度よく高速度で行うことができる。

【0041】一方、上記レーザ加工装置は2つの光学ヘッド15を備えている。そのため、2つの光学ヘッド15を併用して被加工物23にレーザ加工を行うこともできる。その場合、複数の加工点に対して異なる強度のレーザ光Lでレーザ加工するには、一対の光学ヘッド15の光減衰板17の角度を順次変更すればよいから、1つの光学ヘッド5で複数の加工点を異なる強度のレーザ光Lで加工する場合に比べて光減衰板17の回転角度の切り換え速度を緩かにすることができる。

【0042】図5はこの発明の第2の実施の形態を示す。以下、同図を参照して説明する。なお、図1に示す第1の実施の形態と同一部分には同一記号を付して説明を省略する。

【0043】つまり、この実施の形態はレーザ光LをX方向とY方向とに走査させて被加工物23に一筆書きの要領でマーキングするレーザ加工装置で、このレーザ加工装置はレーザ発振器11を備えている。このレーザ発振器11から出力されるレーザ光Lの光路には第1の駆動源18によって回転角度が設定される光減衰板17が配設されている。この光減衰板17によって強度が設定されたレーザ光Lはパワーモニタ19を通過してXスキャナ31に入射する。このXスキャナ31から出射したレーザ光LはYスキャナ32に入射し、ついでこのYスキャナ32から出射して集光レンズ33で集束され、XYテーブル24上に載置された被加工物23を照射するようになっている。

【0044】上記第1の駆動源18、上記Xスキャナ31のX駆動源31aおよびYスキャナ32のY駆動源32aは制御装置34によって駆動制御されるようになっている。

【0045】つまり、上記第1の実施の形態と同様、レーザ光Lの強度を設定するために第1の駆動源18を駆動して光減衰板17の回転角度を設定すると、上記第1の駆動源18による光減衰板17の回転角度が求められる。この回転角度から上記光減衰板17に対するレーザ光Lの入射角度 $\theta_1$ が求められるから、既知である光減衰板17の屈折角 $\theta_2$ とによってレーザ光Lの光軸のずれ量dが上記(1)式に基いて算出される。

【0046】光軸のずれ量dが求まると、上記(3)式

に基いて被加工物23上におけるレーザ光Lのずれ量dxを算出されるから、この算出値より上記(5)式、および(6)式に基いて補正を要する回転角度 $\theta_H$ を求めることができる。

【0047】レーザ光Lの光軸のずれ方向がX方向であれば、回転角度 $\theta_H$ に基いてXスキャナ31の駆動が補正され、光軸のずれ方向がY方向であれば、回転角度 $\theta_H$ に基いてYスキャナ32の駆動が補正される。X方向とY方向の双方にずれているときには、Xスキャナ31とYスキャナ32との双方が補正される。

【0048】それによって、レーザ光Lを被加工物23上でX方向とY方向とに走査させるマーキングを、高精度に行うことができる。この実施の形態においても、レーザ光Lの光軸のずれにともなう補正を、Xスキャナ31あるいはYスキャナ32で行わず、被加工物23が載置されたXYテーブル24で行うようにしてもよい。

【0049】この発明は上記各実施の形態に限定されるものでなく、たとえばレーザ加工装置としてはマーキング装置に限定されず、切断装置、孔明け装置、熱処理装置などレーザ光の強度を変えて加工を行うことが要求されるレーザ加工装置であれば、この発明を適用することができる。

【0050】

【発明の効果】請求項1乃至請求項3の発明によれば、レーザ光の強度を変えるために光減衰手段の回転角度を変えたときに、その回転角度からレーザ光の光軸のずれ量を算出し、その算出値に応じて被加工物を照射するレーザ光の照射位置を補正して照射するようにした。

【0051】そのため、被加工物を異なる強度のレーザ光で加工するために光減衰手段を用いることで光軸シフトが生じても、そのレーザ光による被加工物の照射位置を高精度に設定できるから、加工精度が低下するのを防止できる。

【0052】しかも光軸シフトを補正するために光路補正板を用いた場合のように、この光路補正板の角度による透過率の変化でレーザ光にロスが生じたり、加工点におけるレーザ光の強度が正確に設定できなくなるということもない。

【図面の簡単な説明】

【図1】この発明の第1の実施の形態を示すレーザ加工装置の概略的構成図。

【図2】同じく光ファイバによってレーザ光が導入される光学ヘッドの構成図。

【図3】同じく光減衰板によるレーザ光の光軸シフトと被加工物上における照射位置とのずれ量との説明図。

【図4】同じくレーザ加工の手順を示すフローチャート。

【図5】この発明の第2の実施の形態を示すレーザ加工装置の概略的構成図。

【図6】従来のレーザ加工装置の構成図。

【図7】従来の他のレーザ加工装置の構成図。

【符号の説明】

11…レーザ発振器

17…光減衰板（光減衰手段）

18…第1の駆動源

20…偏向ミラー

21…第2の駆動源

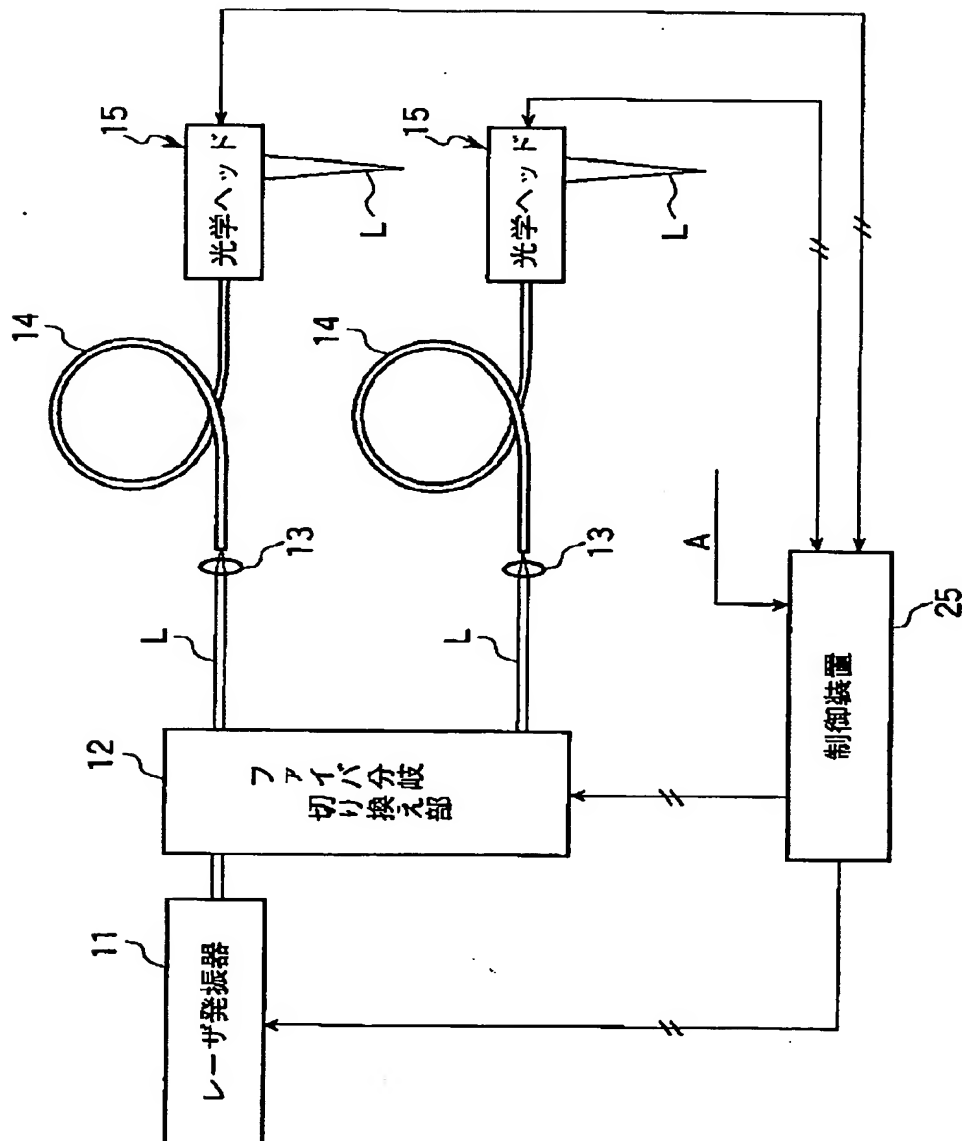
24…XYテーブル（補正手段）

25、34…制御装置（補正手段）

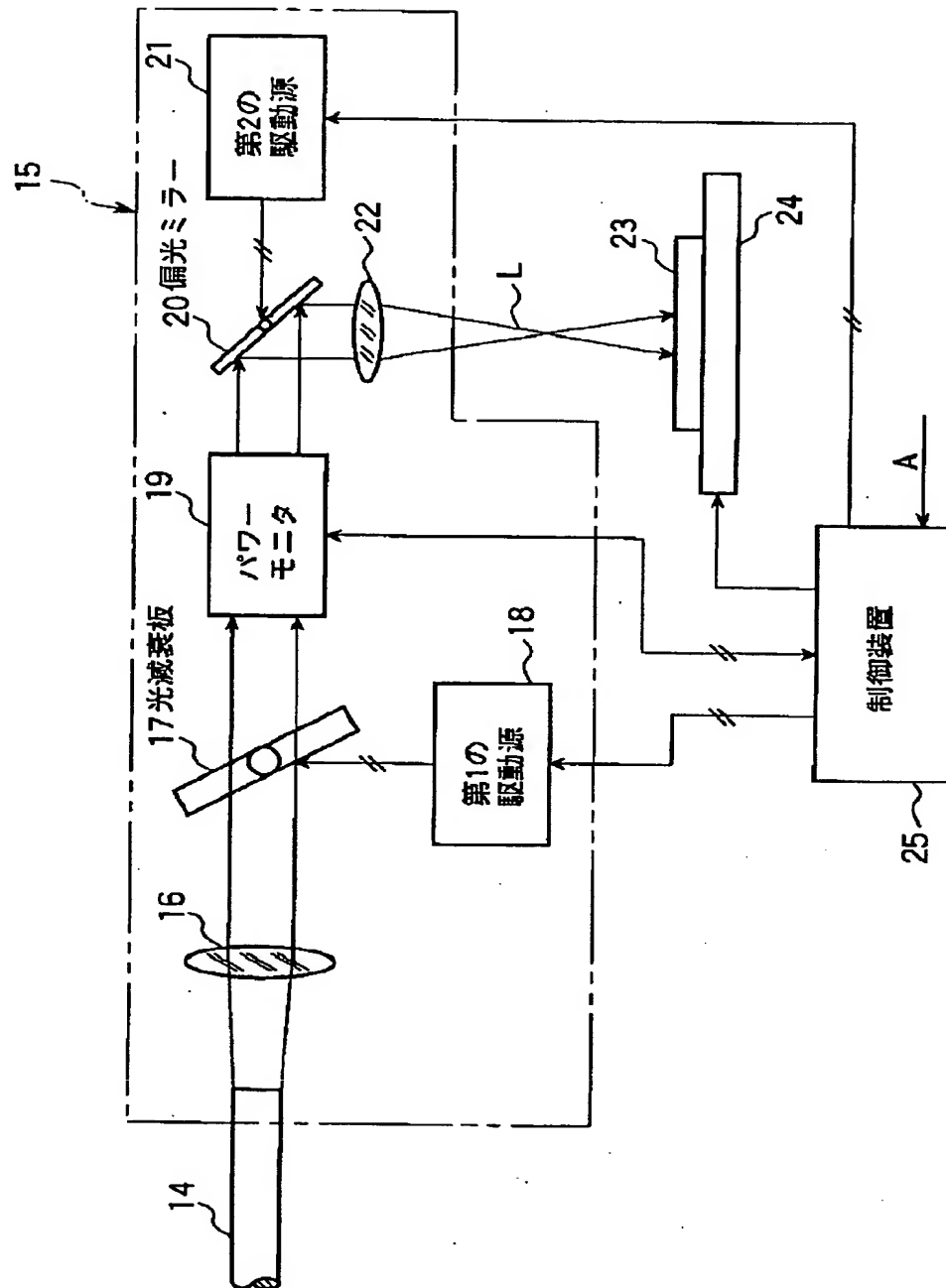
31…Xスキャナ

32…Yスキャナ

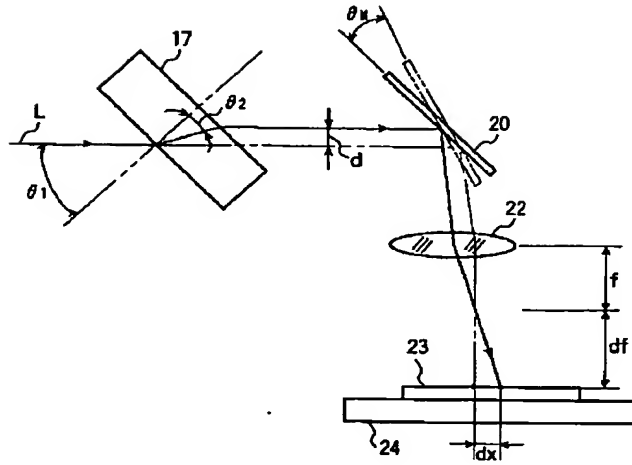
【図1】



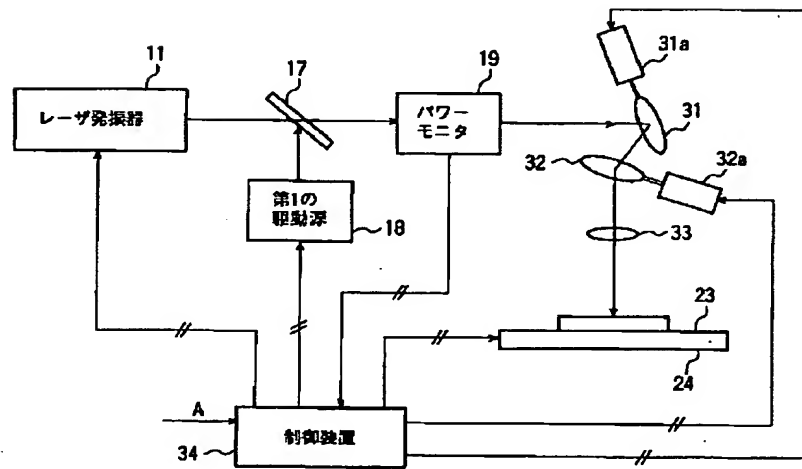
【図2】



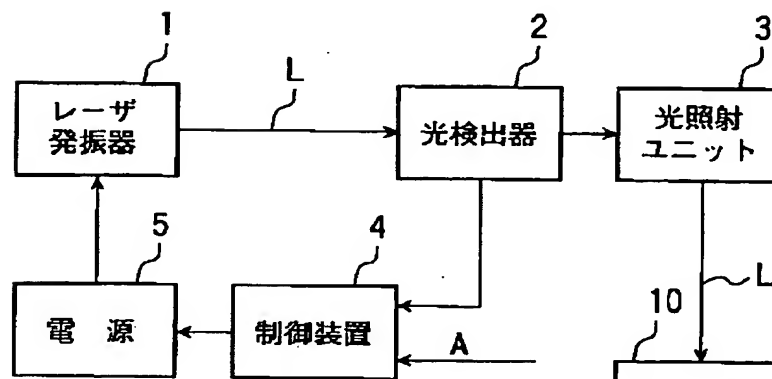
【図3】



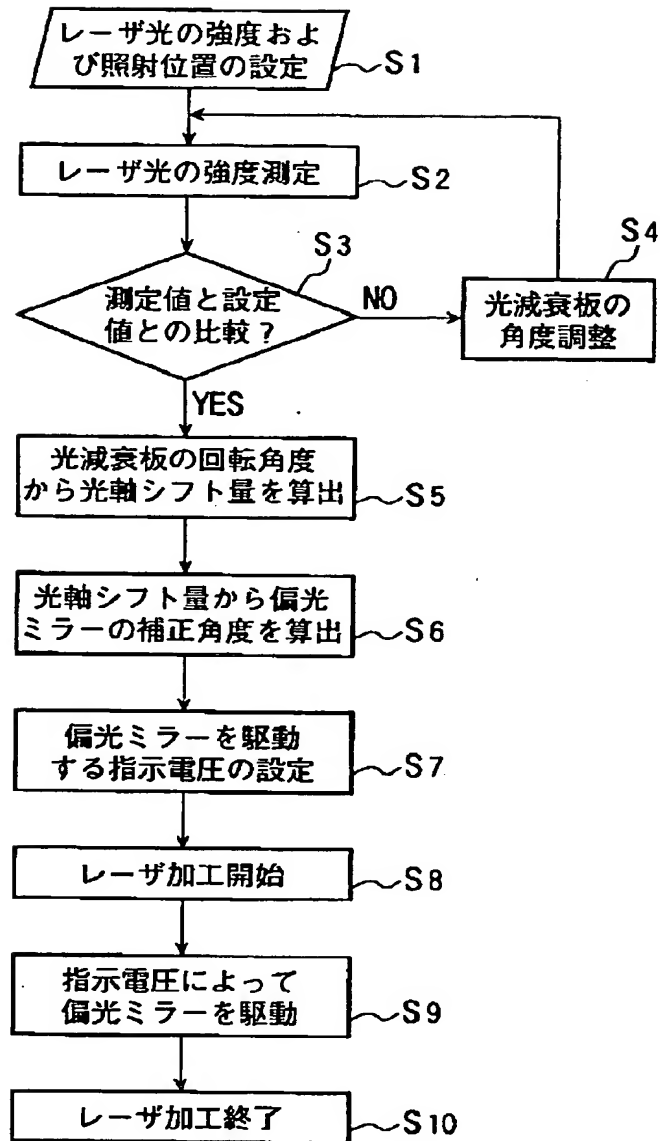
【図5】



【図6】

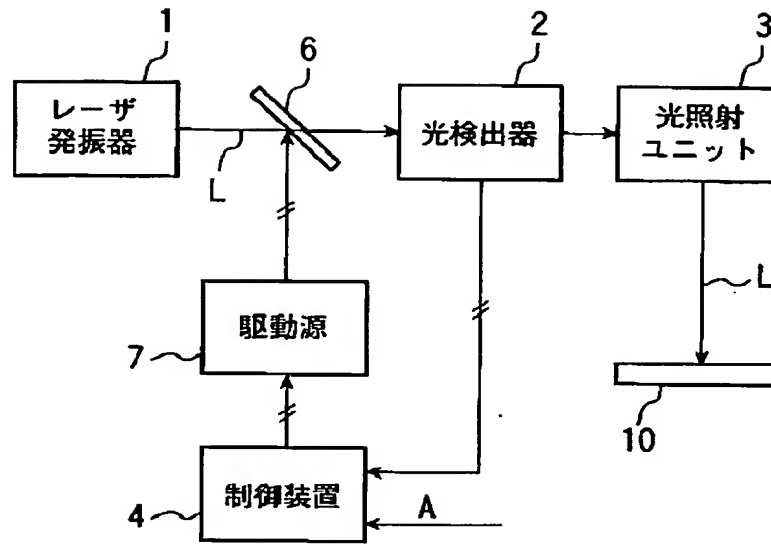


【図4】





【図7】



フロントページの続き

(51)Int. Cl.<sup>6</sup>

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